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INVISIBLE RADIANT ENERGY AS THE CAUSE OF CATARACT

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There is no unanimous opinion as to how much and which kind of visible or invisible radiant energy may reach and pass through the various tissues of the eye without causing damage or at least changes of such character as to impair vision. Some physiologists explain the development of lenticular opacities through the metabolistic influence of the short ultra-violet ray, while others are more prone to believe that these opacities are caused by chemical coagulation of proteins produced as a result of the absorption of the longer infra-red ray by the tissues of the crystalline lens and ciliary body.

Sheard[1], in 1922, brings this out clearly as follows: "The extent of our knowledge of the influence of radiant energy of specific kinds and amounts upon the human eye and hence indirectly upon the comfort and efficiency of human beings is as yet very limited. We have, for example, two rather divergent and apparently conflicting ideas as to the influence of radiant energy as a causative element in the production of cataract. Both of these views may be found to be comparable, however, either the infra-red or the ultra-violet may superinduce cataract under certain physiologic conditions of which we are, as yet quite in the dark. It is this knowledge of physiologic conditions and of the physiological reactions that light of various wavelengths produces, which we in large measure lack. Some of the earliest work done on the relation of radiant energy and the eye was carried out by Schantz and Stockhausen, who concluded that the ultra-violet is injurious to human vision and to the ocular organism by virtue of the fact that certain of the shorter wavelengths known as ultra-violet (roughly, those below 4,000 Angstrom units, which is taken as the limit of the visual violet of the spectrum) are transmitted by the cornea and are absorbed by the lens, causing the lens to fluoresce. This fluorescence interferes with the sharpness of vision and hence causes a constant lenticular irritation whereby the lens

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repeatedly endeavors to sharpen the vision by slight changes of focus. In addition, when large quantities of such ultra-violet radiations fall upon the eye, there is developed what is called ultra-violet burn. These effects come on several hours after exposure, evidencing excessive lachrymation, severe headaches and eye aches and often paresis of accommodation. The symptoms disappear in general rather slowly and often leave a permanent weakness of the eyes. One permanent effect is hypersensitiveness to bright light, but particularly to short wavelengths.

"The writer knows of several physicists and engineers who have used ultra-violet sources of light for experimental purposes and who did not properly shield their eyes, with the result that ultra-violet burns developed and left permanent eye weaknesses. We feel positive from our observations that one such burn will develop latent hyperopia into a manifest hyperopia, ultimately demanding correction and that the sensitiveness to all kinds of radiant energy will be increased, thus demanding the high-powered sources of light be avoided and that the light under which work is carried on be well diffused and toned as is accomplished, in part at least, by our indirect lighting systems.

"As to whether or not there is any direct, specific action of ultra-violet upon the retina is questionable. At least, we are positive that very small quantities only of the shortest wavelengths ever reach the retina. It is probable that retinae which are very thin and highly supersensitive to light may be effected. Certain experimenters believe that evidence is at hand to show the action of such wavelengths upon the ganglion cells and the cells of the nuclear lavers, resulting in chromatolysis (pigmentation) and vacuolation(the formation of vacuoles, a clear space in a cell filled with air or fluid) of the cells.

"Within the past two or three years Dr. W. E. Burge has carried out a series of extremely interesting experiments upon cataracts produced in the eyes of fish living in water containing small percentages of calcium chloride of sodium silicate. Chemical analysis of many hundreds of cataractous lenses from India and the United States have demonstrated the high percentage of calcium (up to 15 per cent) in the ash of such cataractous lenses. It is well known to all persons interested in eye work that cataracts are extremely common in India, and, in general, people living in the tropics. Analysis also show large quantities of silicates, while no silicates are found from the United States. Silicates may be accounted for in part by the fact that certain sects or classes in India eat siliceous earths as part of their diet, while the prevalence of cataracts may be accounted for by the large amount of ultra-violet radiation present in tropical sunshine and the silicates present in the eye media. Burge has, therefore, endeavored to prove the relationship between the interaction of ultra-violet light and the proteins of the lens and chemical salts to account for cataract. Very briefly stated, we (Sheard) be-

lieve that it must be contended from his experiments that where excessive salts exist in the humour and nutritive sources of the lens, there is added the liability to cataractous conditions.

"On the other hand, we find some valuable work, as for example, the researches of Hartridge and Hill of Cambridge, England, in which the seat of the irritation leading to cataractous conditions may be attributed in many, many cases to the infra-red or long wave-lengths of energy. These are freely transmitted by the cornea and are absorbed, claim these men, in large part by the iris, which, lying close to the lens and being the seat of the absorbed energy, will cause nutritional changes in the lens by virtue of the abnormal stimulus to the processes controlling the secretion of the humour. 'Such a view,' said Sheard, 'seems entirely reasonable and probable.' "

To be sure, a number of physiologists, scientists and optometrists, among them, Imre, Pineles, Kuabara[2], and Neill[3], believe that these invisible radiations have little if anything to do with the development of cataract, rather claiming that these lenticular opacities are the result of constitutional abnormalities producing toxins, which, entering the blood stream, produce in turn a condition known as faulty metabolism or, in other words, destructive changes in the cell structure of the lens.

However, the writer proposes for the time being to ignore this last mentioned theory, leaving it to other investigators, and in this paper to suggest a series of experiments on patients themselves, to prove or disprove if possible the theory that radiant energy does produce changes in the lens structure recognizable to optometrists as cataract believing as does Sheard[4] that light, either by virtue of its kind or quality, may aid in or be the primary cause of cataractous formations when certain physiologic conditions are present.

It is well at this time to clearly note that two schools of thought along this line of reasoning have developed during recent years, the first group believing that the ultra-violet radiations are the cause of lenticular opacities, the second believing rather that the infra-red are the cause of these cell changes in lens structure. I will first quote from the writings of a few of those who believe that the ultra-violet radiations are responsible.

Weiss[5], in a paper read before the Optical Congress at Oxford, England, in the fall of 1927, claims: "It is well known that strong intensities of light are harmful to the eyes and that especially the ultra-violet radiation produces injury and inflammation," also saying that, "Harmful effects of ultra-violet radiations last, therefore, for a considerably longer time and this even if the intensities have not been at all excessive." He also states that: "Ultra-violet radiations effect all the outer and inner parts of the eye and cause acute inflammation of the eye lids, the conjunctiva, and the cornea," claiming also that: "It (the effect) becomes noticeable only some time after

the exposure and in altering chemically the media by which it is absorbed. The conclusion, he goes on to say, "to be drawn from these figures is that no protection is necessary for infra-red nor for the visible radiations, as they are always below the endurance limit intensities, but on the other hand, that protection is necessary against ultra-violet radiation."

Van der Hoeve[6] claims, along the same line, that: "The continual everlasting radiation of the few ultra-violet rays on the ciliary processes, will be able in the lapse of years to cause small changes in the epithelial cells, so that the secretion is changed a little. Even a very trifling alteration of the aqueous is sufficient to cause malnutrition of the lens * * *." Following the same line of thought as Weiss and Van der Hoeve, Giles[7] claims that, "In spite of opinions to the contrary, the evidence admits of little doubt but that ultra-violet light, helpful as it has proved to be in other parts of the body, is harmful and even dangerous to some internal parts of the eye." He also says regarding the ultra-violet radiations that, "If used in lower concentrations it increases the liability of the colloid system of the lens and diminishes the glutothione content, both of which reactions, while they leave the lens optically clear, predispose the patient to subsequent incidence of cataract." And further that, "It has been shown that ultra-violet light causes the coagulation of protein which is recognized clinically as lenticular opacity." The conclusions he draws being as follows: "Thus it will appear from research work on the subject by eminent authorities that a chemical change is induced in a lens exposed to ultra-violet light and cataract may ensue as the result."

Sir William Crooks[8] while not going as far in his statements as either Weiss or Giles do in theirs, has this to say regarding the harmful effects of the ultra-violet ray upon the eyes of the workers in the glass-blowing industry. "Taking the ordinary limit of visibility to lie between 3,900 Angstrom units and 7,600 Angstrom units, it is seen that with an exposure of three hours to the highest heats, the strength of impression does not extend much into the ultra-violet. The heat rays are very strong and if injury to the eye is caused by exposure to radiation from the molten glass, a protective glass should be opaque to infra-red rays. These being present in the radiation from molten glass in far greater abundance than the ultra-violet rays, the inference is that it is to the heat rays rather than to the ultra-violet rays that the glass workers' cataract is to be ascribed.

"It is, however, certain that exposure to excess of ultra-violet light also injuriously affects the eye. That the ultra-violet rays act on the deeper-seated portions of the eye is shown by the intense fluorescence of the crystalline lens induced by these rays. Beside the invisible rays at each end of the spectrum, the purely luminous rays, if present in abnormal intensity, are found to damage the eye. It, therefore, would be an advantage if in addition the obscuring glass

for the spectacles were to be of a neutral or gray tint." He says further that, "When no special protection against heat radiation is needed, the choice will rest on whether the ultra-violet or the luminous rays are most to be guarded against; or whether the two together are to be toned down." His experimental work on this subject gave glasses which cut off practically all of the ultra-violet rays and also a considerable amount of the infra-red.

In this manner do those scientists and physiologists set forth their claims of the injurious effects of ultra-violet radiation on the tissues of the eye. On the other hand, there are men who do not believe such ultra-violet radiations as ordinarily received by the eye are harmful preferring rather to believe that lenticular opacities are partially or entirely due to the infra-red radiations rather than the ultra-violet. These men make the following claims:

"Irradiation with ultra-violet rays never caused cataract," says Chmura;[9] "for the rays shorter than 3,000 Angstrom units cannot pass the cornea and only cause superficial changes such as snow-blindness and inflammation to the outer layers of the eye. The ultra-violet rays from 3,000 Angstrom units to 4,000 Angstrom units reach the lens but are absorbed by it—the rays causing only slight changes in the epithelium of the capsule."

Bagwell[10] in his monograph on this subject says, "That it (ultra-violet rays) causes sunburn of the skin, conjunctivitis in some instances, and is chemical in its effect in other ways is an established fact, but that it has ever of itself, if any way, injured any of the deeper structures of the human eye has not been established * * *."

Inre[11], too, claims that, "Ultra-violet rays shorter than 3,000 Angstrom units do not pass the cornea and cause only superficial changes, those between 3,000 and 4,000 Angstrom units are absorbed by the lens, the absorption being greater, the older the patient,"

"If heat and glare from red and infra-red radiation," says Tavs[12], "be responsible in a large measure for senile cataracts, even though there are other definite contributing causes, preventive measures would include protection from that end of the spectrum made up of the longer wavelengths."

Now on what data do these later men base their claims. Duke-Elder[13] and for that matter also Sheard[14] in individual researches found that the crystalline lens had little or nothing to do with absorbing the ultra-violet rays below 3,400 Angstrom units. It had, to be sure, something to do with absorbing the invisible ultra-violet rays from 3,400 to 3,800 Angstrom units and all of the visible spectrum from this point on up to around 8,000 Angstrom units. In addition to this all of the long invisible infra-red rays from 8,000 Angstrom units to around 17,000 Angstrom units reach and are partially at least absorbed by the crytalline lens. In other words, while comparatively little of the ultra-violet radiation reaches the lens, it being largely absorbed by the cornea and aqueous, all of the visible and

invisible heat-producing rays of the spectrum from 3,800 to 17,000 Angstrom units do reach it, and must be, in part at least, absorbed by its tissues. It is for this reason that changes in the lens structure are attributed by these men to the infra-red ray rather than to the ultra-violet ray.

To quote at some length from Duke-Elder on these changes of tissue, "Above the upper reaches of the visible spectrum it will be seen that the rays of wavelengths about 20,000 Angstrom units in the long infra-red are completely absorbed by the cornea. There is a band of relative transparency from about 18,000 to 16,000 Angstrom units, where about 50 per cent of the incident energy gets through, until it is ultimately absorbed by the lens. A region of high absorption follows, until the neighborhood of 13,000 Angstrom units is reached when the transparency again suddenly rises. At this point 80 per cent of the heat energy falling upon the cornea is transmitted and below this the proportion steadily increases until in the region of 7,700 in the red, practically all the incident rays pass into the interior of the eye * * *."

"Considered as a whole, the media of the eye absorbs practically all the infra-red radiation above 12,000 Angstrom units, below which an ever-increasing amount reaches the retina until at 9,000, 90 per cent and at 7,700 practically all of the energy incident on the cornea is thus transmitted * * *."

"Infra-red rays have been found by many observers to produce cataract experimentally: Richen (1914), Vogt (1912-1915), Brinella (1914), Mueller (1924), and Kranz (1925). With severe exposures the writer (Duke-Elder) has produced an opaque disc-like opacity in rabbits, involving the anterior capsule and the outer layers of the cortex, five minutes after radiation; with less intense exposures, a diffuse opacity occurs throughout the lens after a longer interval; with still less, a posterior opacity develops after some days. Under experimental conditions a similar pathological change is difficult to produce by ultra-violet light, owing to the difficulty in getting sufficiently short-waved radiation through the anterior structures of the eye * * *."

However, these conclusions of Duke-Elder cannot be considered at all final, inasmuch as he also has this to say regarding the action of the long-waved ultra-violet rays, *i. e.*, the portion of the spectrum between 3,400 and 3,800 Angstrom units, those ultra-violet rays which are, in part at least, absorbed by the lens:

"In the passage of light through the eye, one other biological effect should be taken notice of, which is associated especially with the lens. Here part of the light gives rise to fluorescence, the region of greatest effectiveness being the long ultra-violet, from 3,500 to 4,000 Angstrom units. This is a phenomenon whose intimate nature is little understood. When light passes through a fluorescing substance the particles of the substance become light sources them-

selves, omitting light of a wavelength differing from that of the incident light, preponderatingly longer, but sometimes shorter. The effect of this phenomenon is regarded differently. Considering that its production implied absorption, Schanz (1915-1922) looked upon it as harmful. On the other hand, from the work of Burge (1915), who cor-related a decrease of fluorescence with an increase in the coagulability of lens proteins, it may possibly be looked upon as a protective mechanism whereby active short waves which might induce coagulation are changed largely into long (visible) waves, by which means their energy, being in a more transmissible form, is disposed of more safely."

This briefly outlines the positions taken by the groups of men comprising the two schools of thought, each believing that one form of radiant energy is responsible for the formation of changes in the cell structure of the lens. But despite the present lack of agreement as to the cause of these lenticular opacities, we, as optometrists, can be safeguarding the eyes of our patients whose visual work is done under such conditions as may prove harmful. This matter is one of vital importance. Under the stress of modern civilization, it becomes more and more necessary to ever guard the visual needs of those many industrial workers and office employes who are forced to work long hours under unnatural lighting conditions. If radiant energy affects the lens, either through the short ultra-violet rays or through the longer infra-red rays, we must take cognizance of this fact and stand ready to prescribe lenses of such type as to relieve this condition.

Not only must this be done for those patients whose occupational needs are such as to require protection, but also it must be done for those patients whose crystalline lenses already show signs of senile opacities. For these patients, Tave, Bagwell, and Block recommend prescribing the formula which gives the patient the best vision, this to be ground in a blue, medium-shaded lens, their experience being the use of optical appliances of this character will go far towards arresting the development of opacities. This technique is based on the assumption that the opacities were originally caused by the chemical action of the infra-red rays on the lens, and that by using a lens which largely absorbs these rays, the development of the opacities would be checked. The writer has had no little success in his own practice with this blue-lens therapy.

However, this blue-lens therapy is based on the assumption that the changes in the cell structure of the lens are due to the action of the infra-red ray, and it is quite possible that this assumption may be faulty. The blue-lens therapy requires the use of a tinted blue lens, either No. 1 or No. 2 in shade, the lens being so ground as to be either 1.9 or 2 millimeters in thickness. A lens of this type absorbs nearly all of the infra-red radiations, transmitting in the No. 2 shade but 8 per cent, yet this same lens absorbs but little of the

ultra-violet radiations, transmitting approximately 80 per cent of these down to 3,300 Angstrom units.

It is therefore evident that, while the blue lenses just mentioned absorb a sufficient amount of the infra-red radiations, they are unsuited for use should the ultra-violet radiations be suspected, Sheard[15] claiming that, "Smoke, amethyst and blue or purple glasses are liable to be a little better than clear glass as a protection against the ultra-violet."

On the other hand, practitioners who wish to eliminate the ultra-violet radiations can do so by having the formulas for their patients made up in either the Crooks lenses or in the Noviol lenses. Both of these glasses are so made as to absorb the ultra-violet, the Crooks lenses absorbing completely below 3,500 Angstrom units and the Noviol lenses absorbing completely all radiations below 4,100 Angstrom units[16], although both glasses transmitted practically all of the infra-red radiations.

Thus, it is evident that the men in each school of thought had at their disposal a means of eliminating the particular set or group of rays they believed most harmful to the tissues of the eye. Those who believed the ultra-violet responsible for harmful coagulation of protein in the lens structures could advise and prescribe the Crooks or the Noviol glass. Those who believed the infra-red radiations responsible for this metabolistic change which produces lenticular opacities could use the medium blue. But each of these therapies had one decided disadvantage. As I have said before, the Crooks and Noviol glasses transmitted nearly all of the infra-red radiations and the medium blue glass transmitted nearly all of the ultra-violet radiations. The practitioner in the field was therefore forced to either ignore the entire matter or else assume a position either on the side of those who viewed the changes caused by the ultra-violet rays with alarm, or else join the ranks of those practitioners who attempted to arrest the development of small lenticular opacities by means of the blue-lens therapy. No one glass was available during the past 15 years which would enable the practitioner to prescribe in such a manner as to eliminate both the ultra-violet and the infra-red radiations at the same time, still giving the patient a sufficient transmission of visible energy so as to enable him or her to carry on with the minimum of discomfort.

To be sure, protection glasses were made, usually for certain occupational purposes, which did accomplish these ends, but these were unsuited for constant wear. They were too heavy and, as a rule, the lenses absorbed too much of the visible radiations to enable patients to use them constantly.

Therefore, several months ago the writer began to cast about to secure, if possible, glasses which would accomplish these ends. Gold-plated Crooks lenses were found to aborb all of the ultra-violet radiations and 99½ per cent of the infra-red radiations but their

cost and their weight, to say nothing of the difficulties encountered in keeping them in order after they were finished, made these impractical.

Mr. E. D. Tillyer of the Research Division of the American Optical Company then came to the writer's assistance. He, at the writer's request, suggested the use of a glass known as Calobar glass. This glass comes in three different shades, all having good protection against the ultra-violet, varying from about the transmission of 5 per cent at 3,650 Angstrom units in the lighest shade to 5 per cent at 3,800 Angstrom units in the darkest shade. He claims[17]: "That the cut-off is very sharp, and as the recent work on the abiotic region of the ultra-violet shows that these rays have no destructive action in the neighborhood of 3,650 Angstrom units, it would indicate that 3,600 to 3,650 Angstrom units is the point where the cut-off should occur. In the infra-red the absorption will vary with the shade. On the piece of light Calobar, 2.35 millimeters in thickness, picked at random, Dr. Coblentz of the Bureau of Standards, Washington, D. C., reports that it transmits 5 per cent, at 3,650 Angstrom units in the ultra-violet, 29.6 per cent in the infra-red and 64.4 per cent in the visible radiations.

"The medium shade, 2.42 millimeters in thickness, transmits 0.6 per cent at 3,650 Angstrom units in the ultra-violet, 14.3 per cent in the infra-red, and 45 per cent in the visible radiations.

"The dark shade, 2.45 millimeters in thickness, transmits 0.1 per cent at 3,540 Angstrom units, 5.9 per cent of the infra-red, and 30 per cent of the visible spectrum. The color of this glass is a neutral green, and it changes color values practically not at all, so little, in fact, that it can be worn by locomotive engineers, inasmuch as it does not change the color of the signals. It has the advantage of having the standard index of ordinary ophthalmic crown glass and corrections can be ground in it, although we have not made a practice of doing this as yet."

Here, then, is a lens which fulfills as fully as necessary the qualifications needed to satisfy for absorption both the ultra-violet and the infra-red radiations. The cost is comparatively moderate and the patient's visibility sufficiently high so as not to impair vision, while at the same time eliminating, for practical purposes, all of the radiations which may prove harmful.

The writer therefore suggests the use of Calobar glass instead of Crooks or Noviol for those cases whose industrial occupations require protection from the ultra-violet or the infra-red radiations and also suggests the use of Calobar glass in those cases with negative histories where small senile opacities of the crystalline lens are already discernible with the ophthalmoscope.

I am not suggesting the use of Calobar glass as a sure cure for cataract. In fact, I believe, with what little data we have before us, such a suggestion would be decidedly premature and would un-

doubtedly result in many unethical optometric and ophthalmological practitioners rushing forth into print with their "sure-cure lenses."

I am, however, seriously suggesting that this body appoint a commission of from twelve to fifteen of its fellows, whose duty it will be for the next five years to prescribe these Calobar lenses of the medium shade, these being fully ground to needed correction, for as many patients as possible who are now suffering from cataract in its incipient stages, the men of this commission to keep in close touch with these patients, making elaborate notations of any developments or changes which may take place in the lens. I am suggesting that only simple cases of senile cataract with negative histories unassociated with other types of ocular pathology be kept under observation, these cases being fully corrected, particularly with reference to corneal astigmatism[18], each case being supplied with two pairs of Calobar glasses, one for distance wear and one for reading, the patients being instructed to return at ninety-day intervals for post-refractions to enable the examiner to record changes in the opacities and also to enable him to improve the patient's visual acuity should any change be indicated, the examiner at the same time reporting the findings of each post-refraction to the chairman of the commission, whose duty it would be to keep all records of both the formulas prescribed, the visual acuities and the changes as noted by the examiner in the size and shape of the opacity.

It is well established that most lenticular opacity cases of this type with negative histories, if ignored, will develop into cases of senile cataract of such character as to require an operation. It is my belief that by means of this therapy with Calobar glass we can check the development of the opacities in a sufficient number of cases to warrant the use of the therapy. This theory can only be proved by putting it into practice and by so doing we can determine whether or not the metabolistic changes in the lens structure are caused by the injurious action of the infra-red radiations and the ultra-violet radiations, or whether the metabolistic changes are due to the effects of toxic influences on the aqueous or the lens structures themselves as carried to these organs by the blood stream. If it is the latter, the use of Calobar glass will have no effect and the opacities will be left to continue to develop as before; however, should the former view prevail, the use of this therapy will unquestionably arrest the development of the opacities in most cases and we can assume that our theories are correct.

The advantages of having a commission work on this research are threefold: The findings have more scientific weight as a result of many workers, the work itself is accomplished in a shorter time than could be done by one practitioner, and last, it would be done under various climatic conditions and on different races of people as found in our various centers.

I can say, however, that with the experience of blue-lens therapy

before me and the Bureau of Standards report on Calobar glass, I am convinced that many cases of senile cataract with negative histories which now are left to develop or "ripen" unchecked can be successfully retarded, thus retaining useful vision without an operation, and in no small percentage of cases I feel safe in predicting that it will be possible to actually report cures.

Time, of course, alone will tell. I have already started these experiments, using human beings as my material. I feel no qualms about this inasmuch as I know that the constant use of Calobar cannot in any way injure the vision of the patient already suffering from incipient senile cataract and its use may arrest the development of the opacities.

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DISCUSSION.

DR. E. E. HOTALING: I have had gratifying results in the treatment of these cases using first the blue lens, shade No. 1 and shade No. 2, but preferrably the No. 1 shade and later the Calobar glass as suggested by the speaker. This, I might add, can be made up in a fused bifocal form which I have found to be of value in some cases. It is interesting to note when so made up, that the reading portion of the lens is slightly lighter than that used for distance and I have felt that this is an advantage as it enables the patient to read or sew more easily.

CASES OF CATARACT TREATED WITH CALOBAR GLASS THERAPY

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This case has a history of failing sight over a number of years. Being the first case of its kind I had ever attempted, I was very frank in admitting I did not know what the outcome would be, other than that I was confident that it would not do the patient any harm. The son was very anxious to try anything to avert an operation, so through his suggestion the mother agreed to the lenses.

I neglected taking the visual acuity in this case mainly because I had very little hope as to the outcome. She was unable to recognize her own daughter twelve feet away, so it was not very good. There was practically no reflex with skiametry because the lens was so cloudy. Being unable to arrive at a correction in that way, I subjectively used minus lenses and prescribed — 3.00 D. Sph., for both eyes, using medium shade Calobar glass. This improved her vision somewhat but not sufficient for her to discern anything on the chart. Three months later she read the 3/10 line with no difficulty, and could count the letters in the 10/10. She felt that if the mist before her eyes would clear off, she could see the letters. There was a nice clear reflex when using the retinoscope, and small opacities noticed during the first examination had disappeared, as well as a definite improvement in the lens cloudiness. She now gets around quite readily alone where prior to the use of this lens therapy it was necessary for someone to be with her when ever she left the house for fear she would get lost or run over.

Two months after this second examination, I saw her again. The lens cloudiness was improved and the 4/10 line could be read easily and part of the 5/10 line could be made out. Skiametry was now possible and a small reduction in the minus was indicated. She is very anxious for a pair of reading glasses, but as yet they are not possible. She and the family are delighted with the results so far

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and never come in the office without making some reference as to their satisfaction.

I will now give a short report of another case. It is that of a lady, age 66. The visual acuity without lenses was: right eye, 5/10, and in the left eye doubtful light perception. The right lens was very cloudy and a number of small opacities could be noticed during skiametry. In the left eye no light reflex with the retinoscope was visible, nor could we penetrate this denseness with the ophthalmoscope. I gave her plus 0.25 D. spheres in medium shade Calobar and since she could see enough to read a little, I gave her cement segments in white glass. I might add that the cloudiness in the right eye was such that it made skiametry very difficult and it was almost impossible to get a picture of the fundus with the ophthalmoscope. One peculiar reaction I have noticed in every case treated with this Calobar lens therapy is that the patient has reported an immediate sensation of ease, or, as two of them called it, "a soothing sensation." Whether this is imagined or real, I do not know.

One month later I saw this case again. The cloudiness in the right eye was greatly improved. In fact, so much so that now I could get a very fine view of the fundus with the ophthalmoscope, and the opacities seen with the retinoscope in the first examination had disappeared. In the left eye, where in the first examination light perception was doubtful, it was now very definite. Also, where there was no reflex in retinoscopy, there was now a narrow, very pale circle as a margin to the iris. It is possible that the pupil was dilated more, but I am of the opinion that it was not. The visual acuity in the right eye had come up to 6/10 and she was guessing correctly at several letters in the 8/10 line, while with the left eye she was now able to see well enough to point to my location in the room. She reports a very positive improvement in all her seeing, which included her reading.

In all, I have heard from three out of seven cases. The results in these three have been very encouraging. I do not know the results in the other four. They may be as discouraging as these were encouraging, and, again, these patients may have had good results.

As to the why of the therapeutic effect of the use of this lens, I can only say that I feel sure there is some effect on the lymphatic circulation in the lens, most probably because some portion of the spectrum is excluded. According to the color therapy advanced by Hessey, green is given the following attributes: soothing to the nervous system; dilates the capillaries; gives a sensation of warmth, and relieves pain; and yellow is considered as a mental stimulant. The Calobar len has a greenish yellow color. I am not contending that color therapy is effective in this or any other condition; I am merely speculating, since nothing is known definitely. Supposing color therapy is not all theory and has some fact. It seems very possible to me that the expanding capillary action that is claimed, combined with the mental well-being and stimulation, would have

a very definite effect for good.

DISCUSSION.

DR. E. E. HOTALING: Mr. Chairman, we are doing some work[1] at Cornell University with Calobar glass. I have now down there about twelve fish tanks, all made of different kinds of glass, some of them made of Calobar, some of them made of glass which has no name, being put out by Bausch & Lomb, as well as blue glass and white glass, and we are subjecting these fish to different kinds of light and producing cataract in some of them, retarding it in others, and doing a lot of different things of that kind. We do not have much definite information yet as to what the final result will be; we are really just collecting data to later arrive at some conclusions.

The difficulty has been, of course, in getting Calobar glass in sufficient size to make tanks out of it. We originally took the small round polished blanks and leaded them together to make these tanks, but just the other day I received the last portion of Calobar for these tanks in 8 by 10 inch sheets.

I think you will find the American Optical Company and all the different companies, for that matter, very easily approached on the subject and very willing to co-operate. It has been my experience that that is so.

I really think this idea of Dr. Koch's for a commission[2] is a very wonderful thing, because I think if you get men working on it in all parts of the country, it will bring some very big results, because unquestionably there is something in it. We have put goldfish in tanks where the glass was white, subjected them to ultra-violet, infra-red, all the different degrees of light, different kinds of light, and some of it produces cataract, some produces corneal ulcers, some produces alkalinity of the aqueous, some produces an acidosis. The theory so far is that the opacities of the lens are produced by an acidosis of the aqueous, and when they reduce that acidosis or resolve it to an alkalinity or an alkaline reaction, the opacity that is produced, which simulates cataract, may not be cataract, it may be just a capsule affair. We do not know that definitely yet, but, at any rate, it produces an opacity which would prevent light from passing through, and that opacity is reduced when the type of light that enters the tank is changed by the interference of these different kinds of glass. I think it is very interesting and I will take great interest in following it up.

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[1] A paper on this subject, by Dr. Hotaling will be presented in this Journal in a later issue.

[2] This commission referred to (see page 334 of this issue) has now been engaged in this work for the past 18 months, under the direction of Dr. E. E. Hotaling, 9 E. 46th St., New York City.

A REPLY TO A CRITICISM ON OCULAR PHYSICAL THERAPY*

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In an article in the March issue of this Journal under the heading of "A Criticism of the 'Newer' Optometry," Dr. Earl J. Dean takes the writer to task for advocating the use of "Ocular Electrotherapy." He says in part: "Although great advances have been made in electrotherapy a uniform technic of application has not as yet been adopted. While electricity is an efficient helpmate in the practice of medicine, the results of value from any mode of application are in direct proportion to the skill of the operator. An authority on electro-therapeutics has said, 'In order to be a successful electrotherapist you must have all the knowledge possessed by the medical man, and, in addition thereto, the knowledge of what electricity will do and be able to apply it accurately.' Does the optometrist have this knowledge? Assuming that he does, he cannot use it without trespassing in a field that is distinctly medical. In event of a serious accident, such as a fatal hemorrhage or the 'going out' of a case of cardiorenal disease, who will sign the death certificate for him?" The authority for this statement is not given but we assume that he is a medical practitioner, however, it really makes little difference, as we fully agree that for any medical man to be a successful electrotherapist he must have a good basic knowledge of medicine and in addition to this he should have a knowledge of electricity and what it will do and also be able to apply it accurately. On this point I am fully in accord with Dr. Dean and the authority he quotes, and I should equally insist that every Optometrist should have a thorough knowledge of Optometry and a basic knowledge of Ocular physical therapy if he attempts to incorporate the latter into the practice of Optometry. For it certainly would be unpardonable for any one dealing daily with human lives as the medical practitioners do, to not have a thorough medical knowledge and we must take it for granted that all the medical practitioners have. We will, however, state and with sufficient facts to back our statement that the greatest majority of the *medical practitioners know little or nothing about electrotherapy or physical therapy.* And how could they know this subject?

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Is my critic not aware that physical therapy was tabooed by the American Medical Association and that that organization branded as a quack any one within its ranks who dared to preach or practice physical therapy, and that it is only within recent years that a resolution was passed at one of the American Medical Association conventions conferring the mantle of respectability upon physical therapy and therefore authorizing medical practitioners to use it. It is one thing to pass a resolution authorizing the men in that profession to use this new form of therapy but with the passage of the resolution the knowledge is not handed down to the practitioners. Where, does my critic think, did the medical men learn about the use of this difficult and interesting subject so that he is willing to grant them a monopoly of it. The answer is they did not learn it, and with the exception of a few isolated cases most of the medical men who apply physical therapy know next to nothing about the subject besides the information passed on to them by the physiotherapy salesmen. This unfortunately is not true only of the men of the medical profession alone but it is equally true of the osteopathic, chiropractic, and optometric practitioners.

I have it on good authority from one of the leading medical lecturers on physical therapy that until a short time ago there was not one medical school in the country teaching physical therapy. Finally Columbia University and Marquette University began teaching this subject and now the subject is taught in only the following twelve medical colleges: Marquette University, Columbia, Leland Stanford, Ohio State, Loyola, Harvard, Rush Medical College, University of Colorado, Creighton, Michigan, Nebraska, and Wisconsin. This represents but 12 per cent of all the medical colleges. What of the students who graduate from the other 88 per cent of the schools? Are they prepared to practice physical therapy and what about the 150,000 medical practitioners in the field now who graduated during the period when this subject was tabooed by the American Medical Association and was not taught in any of their medical colleges?

These statements show, I believe, three things clearly. (1) That present day medical practitioners certainly have no monopoly of the knowledge on this subject. (2) That they do not know enough about the subject to entitle them to a complete monopoly of this field. (3) That the medical profession was not the first to teach, or permit its members to practice physical therapy. Hence, I believe, Dr. Dean to be inconsistent, in the light of these facts, when he wishes to claim not only priority right but also exclusive right for medical practitioners in this field. At another point in his criticism Dr. Dean states: "When it comes to electrotherapy we pretend to no knowledge of the theory or technique. For us to attempt an appraisal of its values would therefore be absurd."

"The obvious fact that the work of all professions dealing with human infirmities at times overlap, is not, we believe, a legitimate excuse for optometric invasion of medical fields . . . "

Now my critic admits that he knows nothing about the theory or technique of ocular electrotherapy yet in the next paragraph he shows his

willingness to wish this subject on to the medical profession and label ocular electrotherapy as distinctly within the medical field. It is his lack of knowledge on this subject (and we all have a lack of knowledge of more than one subject) which is responsible for the stand he takes and his willingness to wish this fertile field of optometric study and practice on to ophthalmology who is, I believe, no more competent to deal with the strictly optometric side of this subject than are we ourselves, and is certainly less interested as its lack of activity in this field would indicate.

Now as many optometrists still lack knowledge of this subject it would probably be best to first define and thus clarify the technic of physiotherapy and when all optometrists get a clear conception as to what we are expounding, they will find, I believe, that they are in perfect accord with us, for after all disagreement in these matters is in most cases the result of misunderstandings. Space will not permit me to go into a lengthy discussion regarding the theory and practice of ocular electrotherapy or physical therapy, for complete information regarding this I will refer readers to my book on the Principles and Practice of Ocular Physical Therapy for Optometrists, which will soon be off the press, and shall here merely try to define Ocular Physical Therapy. In this connection it should be noted that Ocular Electrotherapy is merely one agent of ocular physical therapy. Ocular Physical Therapy is the study and application of physical agents on the human eye which will restore to normal the functioning power to organs, whose functions have proven to be *physiologically abnormal.* It deals with application of those physical agents which are the results, developments, and achievements of applied physics, of heat and light and which are readily adaptable to the practice of optometry and form a natural part of that profession.

The study of ocular physical therapy is mostly a study of physics. The subjects involved are (a) mechanics, (b) electricity, (c) light, and (d) applied psychology, and their effects on the human organism. In the application of physical therapy, we utilize the principles of applied physics, and because of the fact that physics is the major part of optometric study and because of the fact that electricity has been proven to be radiant energy in a modified form, and the entire practice of optometry is composed of the study and application of light "radiant energy," *ocular physical therapy, therefore, from a logical standpoint, forms a natural part of the practice of optometry.* Does not the practice of optometry consist of the application of physical agents? The application of most of these agents is nothing more than the application of "radiant energy" of one form or another. No one certainly will question our right to study and apply radiant energy in our work, because this is exactly what the optometry laws passed by the different state legislatures authorize us to do. What are we doing in our offices when we refract a pair of eyes? Are we not constantly using physical agents? Of course, we are. When we prescribe lenses or prisms, we use physical agents. When we incorporate a tint in a lens we are dealing with "radiant energy" and we are prescribing physical agents. When we administer oculo-prism treatments, or muscular exercises, we

are most certainly using physical agents. When we follow this line of reasoning closely, we can see that this analogy between the practicing of optometry and ocular physical therapy is not merely an analogy but is really an identity. Hence, our claim that ocular physical therapy is a natural part of the practice of optometry.

The Question of Legality

It may be proper to discuss briefly the legal side of this question which is of as much importance as the ethical and moral aspect. From our own standpoint we are satisfied that it is legal for us to apply ocular physical therapy, and some of the leading jurists in the country before whom the greatest battle for optometric recognition was fought, seem to uphold us in our contention. All older practitioners remember that famous legal battle in Pennsylvania during 1914 when optometry was fighting for its very existence, when Judge Wilson, before whom this case was tried, handed down the decision in favor of optometry. In his decision he takes up the arguments of the opposition and discussed each point fully. He[1] disagreed with the contention of the Pennsylvania State Medical Association who claimed that optometry by prescribing glasses was practicing medicine and he made the following analogy: "We cannot regard the fact that the work done by the eye specialist physician and that done by the optometrist, to a certain limited extent, lap over each other, constitutes the optometrist a practitioner in medicine. Such work on the part of the optometrist was done by him perhaps and probably long before the eye specialist among physicians had either the knowledge or the skill to do the work which is now done by both physician and optometrist. *It is to be supposed that reputable physicians, as a part of their practice, at times resort to the use of electricity and massage as a part of their method of treating diseases. Would it be fair application of the statutes in question to say that every masseur and every electrician was practicing medicine because he applied massage or used electric apparatus in the same way the physicians do or have done?"* This statement by Judge Wilson means much to us. It means that no school of practitioners is to be deprived of the right to use any physical agent or agents, because some of these agents are at times used by practitioners of other schools. If high frequency, diathermy, or ultra-Violet rays are used by some medical or other practitioners, it does not become medical diathermy, osteopathic high frequency or naturapathic ultra-violet. It all simply means that the different therapeutic currents which are all "radiant energy" are at times as such applied by some medical men but this does not cause the electric currents to become medical electricity any more than their application by an osteopath or optometrist causes them to become osteopathic or optometric electricity.

It may be of interest to mention at this point that while some of the optometrists are debating with themselves as whether or not ocular physical therapy is within their sphere, other professions at the same time are forging ahead with these therapies very rapidly. For instance, when the writer lectured in Boston recently, he learned that there was going to be held during January of this year a series of lectures and clinics on

dental physical therapy. Classes in this subject for dentists were also conducted recently here at Minneapolis and in other central western cities. This, to our knowledge, is the first time that the subject of physical therapy was introduced to the dental profession in an organized manner.

Now let us ask ourselves this question. Is the dentist, from his studies in physics better prepared for the study and application of physical therapy than the optometrist? Certainly the optometrist from his studies of physics and his daily application of radiant energy has as good as preparation and has as much of right to the study and application of physical agents (physical therapy) as the osteopath, chiropractor or dentist. It may also be of interest to learn that from our conversation with many dentists who attended the physical therapy classes, none of them stopped to question whether physical therapy is within the field of dentistry. All they were interested in was, "will it improve their technique?"—"will it enable them to render a better service to their patients?"—and that is exactly what we optometrists should be interested in. If ocular physical therapy will improve our optometric technique, and if it will enable us to render our patients a better service, then there should be no question as to the advisability of adding it to our practice. Many of us who have been using it for some time are satisfied that it does these things, and we are informed by some educators that no court would prevent a practitioner from using a certain agent or agents which use improves his various other technics and thus enables the practitioners to render a better service to his patients.

Ocular Physical Therapy As An Aid to Optometry

Optometrists will find that the application of ocular physical therapy will tend to shorten the treatment period in muscular imbalance and amblyopic cases. It will help arrest the development of incipient senile cataract and in some cases will aid in having the lenticular opacities absorbed altogether. There are a number of cases on record to substantiate these claims. It is one of the best agents in relaxing spasmodic muscular conditions, hence it may prove invaluable in case of spasm of the accommodation. In myopic cases where the condition is due to a low calcium content in the blood stream, local ultra-violet applications may prove of value. It is, I believe, a help in the development of vision in amblyopic cases, and as a pain relieving agent it has no equal.

Ocular Physical Therapy may Prevent the Development of Pathology. The general trend among practitioners of different schools is toward preventative rather than restorative work. In applying ocular physical therapy intelligently, the optometrist has a means at his command which will help him prevent, in some cases at least, the development of pathology. Helmholtz,[2] DuBois-Raymond and other more recent investigators have shown that when a muscle is overworked, special toxic substances are produced which cause fatigue of the muscular and nervous system. Abelous thinks that fatigue causes a sort of auto-curarization or paralysis of the terminal motor plates of the nerves which actuates the muscles. The synapses become more resistant to the passage of the nerve current when the axons

and dendrites are effected by toxins due to fatigue, or drugs, etc.

This causes a slowing up of the nerve energy flow. The muscles which depend for their nervous energy upon these effected nerves suffer and fail to function properly. This stage marks the beginning of a condition known as *physiological inactivity,* which if not cared for promptly will develop into a condition of *pathologic inactivity.* As mostly all pathologic conditions are preceded by a condition of physiologic inactivity, it becomes of extreme importance, from a preventative standpoint, that something should be done to restore the normal nerve energy flow across the synapse to the muscle and in this way to reestablish normal physiologic activity and thus prevent the development of pathology. Almost all authorities agree that the proper application of physical agents such as therapeutic currents will help remove the condition which caused the synaptic resistance and the blocking of the nerve energy flow which in turn is responsible for the development of the physiological inactivity. From the preceding discussion, we may safely conclude that the proper and timely application of ocular physical therapy by optometrists as a complement to other accepted optometric techniques will not only be a great help in the treatment of ocular abnormalities such as amblyopia, cataract, muscular abnormalities, astenopia, etc., *but will help prevent the development of pathology. It will thus open up a new field in preventative optometry.*

A Proper Conception Needed. In order that one may be able to decide whether or not it is advisable for him as an optometrist to add ocular physical therapy to his practice, it is of utmost importance that he first have a proper conception as just what is meant when we advocate the use of physical therapy by optometrists. Some close their eyes and draw an imaginary picture that it means the adding on of a new profession to the practice of optometry, for instance the absorption of the chiropractic group, or the naturopathic practitioners into Optometry and then that the optometrist will not only practice refraction and all that goes with it, but he will also be a physical therapist and will apply it not only to the eye but to the body in general, much the same as the practitioner of medicine, chiropractic or osteopathy are now applying it. It is this misconception which causes some optometrists to be somewhat undetermined as to whether or not they should add ocular physical therapy to their practice, and a clear cut and favorable decision is usually only reached after one gets a clear conception as to what we actually do advocate. That this is the case, we were in a position to learn during a recent lecture tour East. A considerable number of Optometrists attended my lectures from the standpoint of curiosity alone. They did not intend to apply this new therapy in their practices. However, after attending the lectures, many had an entirely different conception of this new subject of ocular physical therapy. A majority of the optometrists who have attended these lectures have already added ocular physical therapy to their optometric practice. This important fact was disclosed by a questionnaire that was sent out during the month of February to all optometrists who had attended lectures asking them whether or not they had added this new technique to their

practice and if not whether they intend to do so in the future.

We were surprised to learn that fully seventy per cent of the men who attended the lectures have already, during this short period of time (two months) added ocular physical therapy to their techniques and the majority of the remainder indicate their intention to add it in the very near future. The fact that this subject aroused a considerable interest among optometrists in all parts of the country, as evidenced from the mass of mail we receive daily asking for further information and from the numerous requests from organizations for lecture dates, indicates that ocular physical therapy is fast becoming a part of optometric procedure. At this point the writer wishes to emphasize this one point again, that we advocate[3] the use of ocular physical therapy as a complement to all other accepted optometric techniques and *not* as a supplement. Also that ocular physical therapy should be applied by optometrists to physiological abnormalities only and not to pathological conditions. Dr. Dean's fear that the optometrists applying ocular physical therapy will have no one to sign death certificates for him in case the patients "go out" on him is not, I believe, well founded, because the milliamperage applied in ocular physical therapy is very low and cannot cause any very serious harm. Dr. Bordier[4], the eminent French electrotherapist, is the authority for this statement, "that diathermia treatments are painless, devoid of risk to the patient and can be continued as long as is desired." Some of us who applied ocular physical therapy for some time are in a position to substantiate Dr. Bordier's claim. I am in full accord with my critic that optometry should not invade a purely medical field but from our discussion in the first part of this article, we have not only shown that physical therapy is not a purely medical field but that its very use was outlawed by that profession for many years. Dr. H. L. Murray in a paper read as late as April, 1928, before the Victoria Branch of the British Medical Association stated that "the treatment by physical agents has been used in some form for all time, but until recently it has not especially been taken up by the medical profession and carried out in a scientific spirit of investigation. Even now it is mostly carried on outside of the profession." It is well also to note that there are many more statements of this kind recorded in the literature on this subject by leading men in the medical profession in this country as well as abroad.

We also wish to call the attention of optometrists to the specific legal aspect of physical therapy in some states. For instance, in Ohio state the law does not permit any practitioner whether he be a chiropractor, osteopath, medical physician or optometrist, to apply physical therapy in his practice unless he takes a special physical therapy examination. It is also interesting to note that an optometrist has been teaching this subject to most of the medical men who are preparing for the Ohio State Board examination.

In concluding the writer wishes to state that the subject of physical therapy is big, and the field is very broad and has many applications. Each profession,—dentistry, optometry, medicine, etc.—should, I believe, not

only be permitted, but encouraged to study and apply physical therapy in their respective practices where and when such application will enable them to render a better service to the public.

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CHROMAGRAPHOLOGY

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Chapter IV
Colour Theory

This entire work, having for its main purpose the clarifying and simplifying of visual interpretations of chroma (colour), has brought us to the subject of colour. The previous chapters developed the importance of our consideration, so that this fourth chapter brings us naturally to this important threshold, and it promises to be a very interesting development. Repeating the part of the statement concerning this chapter which appeared in chapter one, let me say that J. E. Sturmer, Dean of Science in the Philadelphia College of Pharmacy and Science, called colour "the great unsolved riddle." He said that science had gone far enough to try to evolve a hypothesis, connecting the phenomenon of selected absorption with the electron theory, but emphasized the fact that a hypothesis is, after all, only a theory on probation, and that speculative thought in science means reasoning from premises not yet proven. Colour is one of the great mysteries, and a mystery is best described as something about which we know only enough to make us acutely curious.

Usually when one thinks in terms of colour, it has been in connection with its cosmetic value, or in association with some ethereal sense. For instance, we have knowledge that colour has a definite bearing on human life. It is said, for example, in connection with experiments upon animals, that when they were kept in white walled rooms they grew fat, while others retained in dark walled rooms, wasted away. This might lead us to a rather interesting experiment if we made such a thought available for the somewhat robust humans who desire to reduce, so that by placing them in a deep purple walled room, the bust measure might be reduced in proportion to the length of exposure. In fact, it might be extended so far that by painting the ceiling black, we might be able to reduce double chins.

The scientists in physiology and psychology have made some very fascinating studies designed to determine the effect of colour in science, so that it has been used with effect in sales programs, and even in the creation of new styles and fashions, and home life, it seems, is also susceptible to the influence of colour.

One famous Englishman has studied the action of colour shades on

vegetable growths, trying to measure the possibilities in the correction of disease. His research has made him a believer in the fact that most every disease can be cured by the application of certain colours. A certain shade of red, for instance, is most effectual in case of blood poisoning. Green increases vitality, while yellow will restore nerves. Just how much of that might be in the end laid at the door of psychological effects, is a matter of question with the writer.

Colours seem to be a factor in shaping our destiny, and do make for good and bad. Therefore, when considering their effects upon character, certain experiments seem to indicate interesting facts. Surround an individual, for instance, with red, and he will develop a fiery, violent disposition, and his conversational efforts will be marked by the effect. It is said that yellow gives warmth to thoughts and produces intellectual effects. Blue, associated with grandeur and depth—the Heavens, the seas, mountains, and distance—develops devotion in man. The effect of colours may be altered by their shades. Certain shades of green, for instance, ordinarily the most soothing of all colours, develop activity and adaptability, while a certain other shade of green will engender jealousy. One could go on for an indefinite space in listing the theories of the many who have attempted, and find by so doing contradictions and reversions which would weaken the whole structure to the extent that it might lose its value. Suffice it to say, therefore, that all colour remains a mystery when we realize that without direct illumination, it fails and cannot be seen. This can be very ably demonstrated if one will observe, for example, a scarf or hanging of brilliant hue—say red, or green, or blue—under the illumination of the sun, or artificial illumination in a room, and then view the same in darkness. It will be found that the brilliant hue first observed has been lost and supplanted by a grey of some shade between white and black. These preceding statements have been mentioned in order to place the reader's mind in a position favorable to the consideration of colour, and to understand why it is that colour is still a question of theory.

In this battle of the ages, to theorize on colour, thus attempting to explain an interesting but illusive phenomenon, a well marked variance has divided the field. We find the physicists, the physiologists, and the psychologists occupying positions quite different, with premises unreconcilable until of very recent months there seems to be a slight clearing, which may lead to a stronger position. There is no doubt that under the capable guidance of some of our more able scientists, a very profound paper could be written on the theory of theories, as the subject has not yet been adequately treated; and in a scientific world where theories are constantly being constructed, it is of great importance that the general principles which govern their efficiency should be thoroughly understood. Upon close observance, one finds that many crimes are committed by some of the current theories against fundamental principles, open even to the comprehension of the simplest intelligence, and it will be necessary to enumerate in a few words the basic principles regarding theories as they apply to colour.

First, it should be the object of each theory to explain itself in a terminology, or at least a common language, so that any two contesting theorists might at least discuss their facts in a comprehensible fashion on a common ground.

Second, we are all aware that the premises upon which this subject must be considered are, as established by fact, partly physical, partly physiologic, and partly psychologic. The principle of psychophysical parallelism must be obtained, and no start in a colour theory can be made without it, unless science could be satisfied with a half-way application.

Third, no element of a theory is of any great positive value unless it explains more than one phenomenon at once. That is to say, it must be able to explain at least two things at one time, and in one statement. In other words, there should be a distinct difference made between those theories which fit in with a large scheme of conceptions, all working together, and those theories which are sufficient only in one point.

Let us, therefore, consider the theory of Helmholtz (modified from Young), that of Hering, and then consider them both in the light of the Ladd-Franklin theory.

Normal colour vision is ordinarily spoken of as trichromatic. It may be defined as that vision in which all colour sensations and white can be produced by retinal stimulation. In view of this fact, Thomas Young, in 1807, formulated a theory, later modified by Helmholtz and known as the Young-Helmholtz, but because of the great and well-deserved fame of Helmholtz, became and is known today as the Helmholtz theory. In this theory it is assumed that the visual mechanism is stimulated in but three ways by all the various wave-lengths of light, whether these act individually or collectively. It was contended that the retina had three distinct types of nerve fibers (presumably cones) which carried their impulse to the brain, thereby giving rise to three fundamental colour sensations, so that the excitation of the first of these fibers, for instance, would give rise to red; of the second to green; and of the third to blue; the stimulation of all three fibers causing the sensation of white, and the absence of all, the sensation of black. This would naturally call for an anatomical differentiation impossible of demonstration, so that the differentiated cone theory was discarded and they became known as the three independent variables existing vaguely somewhere between the retina and the brain. This brought forward the name of the "three components" theory; and in order to explain the production of other than the three fundamental colour sensations, Helmholtz held that all wave-lengths affected all three elements, but not to the same extent. For instance, the longest vibrations stimulate the red element very greatly, the green moderately, and the blue but little. The shortest vibrations excite the blue most, the green moderately, and the red but very slightly. Hence, it would be necessary to understand any sensation to be the result of the sum total of three stimulations, and it thus became known as the "additive" theory. The Helmholtz theory explained satisfactorily the mixing of colours, and accounted for colour-blindness by the absence of one or two of the three elements. This

led the theory into deep water and required modification. Negative after-images were explained as being dependent on the lower sensitivity of the retina to subsequent stimulation, explained by the three component theory.

Let us turn to a very able scientist, Dr. W. D. Zoethout, for his criticism as explained in a book "Physiological Optics." He says:

> "In many respects this theory falls short. Simultaneous contrast, or spatial induction, as we have seen in Chapter XVIII, Helmholtz explains not in terms of his colour theory, but as an error of judgment, thereby giving it a pure psychological basis. Another difficulty encountered by this theory is that of achromatic (colourless or white) vision in very dim light (scotopia) when all wave-lengths of light are seen colourless. For example, the theory is hardly able to explain why in scotopic vision green light, i. e., ether vibrations of 526 milli-microns, should arouse the sensation of white.
>
> Luminosity is regarded by the Helmholtz theory as the sum of the excitations of three colour elements. But colour vision and luminosity may vary independently very largely. The light sense and the colour sense may be impaired separately, and therefore, it seems as if there are two distinct mchanisms in one visual apparatus, the one chromatic, the other achromatic. We find an illustration of this in the totally colour-blind. Unless the Helmholtz theory is so extensively modified as to almost lose its value, a totally colour-blind individual should also be totally blind to white light. Its advocates argue that in this condition the three retinal elements become of equal value; that is, they are all stimulated to the same extent by all ether waves. This saves the theory in this respect, but complicates and correspondingly weakens it.
>
> Even the more simple forms of colour-blindness are not fully explained. A red-blind person perceives only two spectral colours, namely, yellow and blue. But if such an individual receives all his visual impressions from the stimulation of the green and the blue elements, as this theory demands, how can he perceive yellow? We should surmise, according to the theory, green and violet, and not yellow and blue, to be the two colours seen in the red-blindness."

From the above it may be seen that the Helmholtz theory is a physical theory, and does not consider in its basis the very necessary psychological factors involved.

Let us now consider the Hering theory, which takes into consideration the existence somewhere in the visual organs, presumably anterior to the cerebral cortex, three photochemical processes, which upon being affected by light undergo chemical changes correlated by the author of the theory, with those occurring in protoplasm. Protoplasm, as is well established, is constantly undergoing changes which make up the process known as metabolism. Metabolism might well be called, in the final analysis, life, when we consider it in its two parts, anabolism and catabolism—catabolism, a destructive change taking place in the decomposition of cell life, and anabolism, a constructive change taking place in the rebuilding of cell life through nourishment and rest. Thus we say that when anabolism is greater than catabolism, the animal (human) increases in weight, and when catabolism is greater than anabolism, the end result is death. Hering, therefore, classified these as autonomous anabolism and autonomous catabolism, based on the fact that for every stimulation there is either an

increase in catabolism or anabolism. Summing this up by saying that there is always a tendency for the dissimilation and assimilation to be in a state of equilibrium, because of the fact that an external stimulation, responsible for an increase in catabolism, caused an increase in the autonomous anabolism, and an increase in the anabolism caused increase in the autonomous catabolism.

Considering then the three photochemical substances to be red-green, the yellow-blue, and the white-black, we will observe briefly how the theory explains each. With reference to the red-green, we find that the red light causes an increase in the catabolism so that this chemical change excites the proper area in the brain to call forth the sensation of red. The green light produces an increase in the anabolism, resulting in the sensation of green. In connection with the red-green, it might be said that Hering speaks of them as complementary colours despite the fact that he makes them so by adding blue to the green.

Likewise, in the yellow-blue substance we find catabolism increased by yellow light and anabolism by blue, while all wave-lengths increase catabolism of the white-black substance, causing the seeing of white. This has brought to the Hering theory the name "opponent colour" theory, and is concluded by the supposition that if we had chosen the correct amount of each colour, the anabolism and catabolism are in a state of equilibrium, so that no colour is seen. Dr. Zoethout has explained this very ably, and the following is taken from his book:

> "Let us suppose that yellow light has been looked at for a considerable length of time. The yellow-blue compound is steadily and very largely catabolized; its further catabolism becomes more and more difficult until finally it ceases. This causes the eye to become blind to this colour. If now white light is flashed into the eye, the yellow wave-length of this white light has no effect; but the blue wave-length influences the yellow-blue compound very largely, increasing its anabolism and thus creating the sensation of blue, the negative after-image of yellow. Even in the absence of the second (white) light, the blue negative after-image may be seen because of the greatly increased autonomous anabolism which sets in during and after the great catabolism caused by the yellow light. It will be noticed that in these after-images the retina is not at rest but is undergoing positive changes either of assimilation or dissimilation. As protoplasm undergoes catabolism more readily than anabolism, it is easier to obtain a green or a blue than a red or yellow negative after-image."

Zoethout further points out that in consideration of this theory, colour-blindness offers difficulties, and says:

> "Many objections have been raised against Hering's theory. A number of facts concerning after-images and spatial induction do not fit in, but we have not space to enter into them. We may just mention the sensations white and black. To physicists black is the absence of light, and therefore, is not regarded as a sensation. Psychologists, on the other hand, speak of it as an actual sensation. Maintaining that black is a special quality of sensation, as truly as red or white, Hering claims for it a separate physiological basis. This basis is the anabolism of the white-black substance. Black, however, is not the sensation we experience in a total darkness, for the intrinsic light of the retina causes a sensation which Hering terms a mean gray. Real black is experienced when we look at a small square of black paper on a white background. Or, it may be seen in the black

> negative after-image of a white light. In both these instances, the black is darker than the black of unilluminated space, and is due to the autonomous anabolism of the white-black substance."

Thus we see that the Hering theory adds a psychological consideration, but is still not scientifically acceptable, so that we will turn our attention to the true psychologist, endeavoring to get his interpretation of visual phenomena from the standpoint of psychological optics, for nowhere is the nature of consciousness more clearly demonstrated than in the visual field, and the relation of mind to body receives its most perfect exemplification with respect to the optic sector of the nervous system. This can be most ably presented by reprinting a paragraph from an article entitled "Optics as Seen by a Psychologist," written by Dr. Leonard T. Troland:

> "Perhaps, when a physicist thinks carelessly, he may identify colour with wave-length or wave-length composition; but the fallacy of any such identification is revealed at once under psychophysical analysis. Infrared or ultraviolet radiant energy is just as characteristic in wave-length composition as is the radiant energy of the visible spectrum, but it has no colour. Colour is, therefore, a fact which may be correlated with wave-length, but cannot be identified with the latter. It should be clear to any logical thinker that corresponding properties of identified things must be exactly similar, but *there is nothing wavy about a colour nor anything intrinsically coloured about a wave-length.*"

This then brings us to a theory of colour developed by one of the most able constituents of the realm of psychology, and for the reason that the writer wishes to be classified among its followers, some space will be devoted to the not entirely necessary, but at the same time extremely interesting, details concerning the personality of the author and the facts involved in the formation of what has been termed the strongest of all colour theories.

Ladd-Franklin, Christine (Mrs. Fabian Franklin), a psychologist and logician, born at Windsor, Connecticut, December 1, 1847, and died March 5, 1930, at New York City. Dr. Ladd-Franklin's interest in the theory of vision took her in 1891 to Europe, where she made researches upon the theory of colour in the laboratory of Prof. G. E. Müller, who not only gave her access to his laboratory, but actually repeated his lectures to her as an audience of one. This doubtless did much to hasten that prying open of the doors of the German universities which took place not many years after. It was while she was engaged in writing an article to show a certain theory by Donders was better than that of Helmholz or Hering, that it suddenly dawned upon her that a far better theory was possible. Therefore, the theory was first announced at the International Congress of Psychology in London in 1892, and has only been strengthened by the scientific attack of the nearly forty years intervening. It is with a great degree of pride that the writer wishes to express appreciation for the very friendly co-operation of this fine soul in his humble efforts expressed by this series of articles.

In passing, the writer wishes to repeat the statement he often makes from the lecture platform that age does not preclude advance and success

where interest is keen. This is very ably demonstrated by a letter from Dr. Ladd-Franklin, copied hereafter, written just prior to and received upon the day of her death.

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK
Department of Psychology
417 Riverside Drive,
February 25, 1930.

Dear Dr. Heather:

I have received at last the review of my book by Professor Woodworth (the head of the Department of Psychology at Columbia). I had told you how very dilatory he has been in writing it, but now that it has come, it is so very flattering that I cannot have any reason to complain.

Moreover, my important paper on the "Non-Existence of Existence" (a delightful title, my friends tell me) will be coming out at once in the Revue de Metaphysique et de Morale. Professor Xavier Leon (the editor) has been wonderfully good in having it translated for me. (Usually they require that you send it over in French.)

I am very glad that you are getting on so well in demonstrating my charts. You will see how much Professor Woodworth admires them. The set which you have is imported. I am having them made in the Hague now. As I told you, they cost one-third as much as in this country; they are three times more beautiful; and by chance, they are also three times more durable. But three times three, times three is twenty-seven—hence they are twenty-seven times more valuable.

With good wishes for the success of your trip, I am
Yours sincerely,
Signed: CH. LADD-FRANKLIN.

When one considers that at eighty-three years of age, the production of a paper on psychology as mentioned above is possible, one gets a measure of the ability of this great woman. Before describing her theory, I wish to present the opinion of Professor Woodworth that she mentions in her letter. The book she refers to is entitled "Colour and Colour Theories," published in 1929, which, incidentally, would be of very vital interest to those interested in the theories of colour:

COLOUR AND COLOUR THEORIES
Christine Ladd-Franklin

Professor R. S. Woodworth (Columbia) in the *Psychological Bulletin:*

The problem of colour vision has fascinated keen scientific minds through the centuries: Leonardo, Newton, Young, Helmholtz, Hering, G. E. Müller, and others; but it is not too much to say that the present work, by its firm grasp of the numerous relevant facts and by its incisive logic, deserves a place even in so distinguished a company. . . . Not only the classical theories of Young and Helmholtz and of Hering, but many more recent attempts are subjected to destructive criticism on the basis of the facts. Though the facts are used as weapons, they are present in such abundance and precision as to make the book a mine for those who are more interested in fact than in theory. . . . If one value of a theory is to hold together a mass of facts, the Ladd-Franklin theory of colour vision is remarkable for its success in integrating the facts of direct colour impressions, of colour mixing, and of rod and cone vision, along with something of photochemistry and of biological evolution.

One advantage of the Ladd-Franklin theory over that of Hering appears in the treatment of black. Both theories—and the Young-Helmholtz theory as well, in order to be complete—have to assume a cortical response as occurring when and where no stimulation is coming from the

retina. The conception of antagonistic colours requires that black shall correspond to actual stimulation coming in from the retina, and so is forced to postulate a medium gray as its background or cortical colour—which postulate forces it into several improbable supplementary hypotheses. The Ladd-Franklin theory is free to select black as the cortical colour corresponding to no stimulation from the retina; and this assumption is shown to work out extremely well.

Mention should be made of the colour charts, which are not only beautifully executed, but very carefully managed to present the colours required; and the Glossary should not be overlooked, with its definitions and important suggestions of standardized nomenclature.

R. S. Woodworth,
COLUMBIA UNIVERSITY.

Also for the reason that this comment comes from the realm of psychology, it is desired that the reader have an opinion from the realm of physics, which is copied from a text-book on physics by Dr. Henry Crew of Northwestern University, located in Chicago.

"GENERAL PHYSICS"
by
HENRY CREW, PH. D.
(Fayerweather Professor of Physics in Northwestern University)
4th Edition

Page 591—

450. *The Essential Facts; The Ladd-Franklin Theory.* As we have just seen, the colour of any beam of light is definitely determined by its refractive index; but it is well for the student of physics to realize that this is, by no means, the whole truth. Colour is also a sensation which is something quite different from the stimulus—the light—which produces that sensation. Newton succeeded in producing white light by adding together all the colours of the solar spectrum; but white light (i. e., the sensation of white light) can be produced in numerous other ways; and it is a fascinating problem to discover the simplest possible viewpoint from which to regard the various phenomena of colour. The essential facts appear to be something like the following:

(i) Colours can be mixed only by superimposing two beams of light. One cannot mix yellow and blue light by adding a yellow pigment to a blue one. The one pigment will either hide the other or at most let through what is left after a more or less complete absorption.

If two pigments are placed side by side and then viewed from sufficient distance the colours may be truly mixed; and this is the basis upon which the impressionist school of painting is established.

Colours are best mixed by superposing the two beams of different colour by means of lenses and prisms; or by taking advantage of the persistence of vision and rapidly rotating a disc with the different colours on different sectors.

(ii) The retina of the eye consists of three zones having the *fovea* (or point of clearest vision) at the center. The outside zone corresponds to the margin of the field of vision and is sensitive only to black and white and, of course, to the blend of these two which we call gray. The middle zone is sensitive, not only to white and black, but also to yellow and blue; while the innermost zone immediately about the yellow spot (fovea) is sensitive to red and green as well—that is, it is capable of furnishing us all four of the chromatic sensations. Vision is here tetrachromatic.

(iii) The mixing of two light rays (whether homogenous or not) gives us, in general, a dual colour blend,—thus from blue and green, mixed in different proportions, we get the whole series of the blue-greens,—from red and yellow we get the red-yellows (popularly called the oranges),—from blue and red we get the blue-red series (purples, violets). There are, however, two remarkable exceptions to this simple rule; red and green when

mixed in the proper proportion give a pure yellow, and yellow and blue (that is red and green and blue) give a pure white—

$$R + G = Y,$$
$$Y + B = R + G + B = W.$$

in either of these cases the resultant of white light is as utterly devoid of colour as pure water is of either hydrogen or oxygen.

(iv) Physicists have not hitherto been interested in distinguishing between the dual colour-blends (the black-whites, or grays,—the blue-reds or purples, *etc.*) and the unitary colours, Y and B, R and G, but no one fails to see, when his attention is called to it that any orange, for instance, is physiologically nothing but some one of the various mixtures of red and yellow. It follows that the number of different colours in the spectrum is four, not seven.

(v) Partial colour-blindness, far more common in men than in women, is atavistic condition similar to that in the midperiphery of the normal retina. The red and green sensations have not been developed. Total colour-blindness also occurs, corresponding to the achromatic condition of the normal extreme periphery.

Various theories have been proposed (by Helmholtz, Hering and others) to explain these phenomena; but the one which appears to summarize all the facts most simply and completely is that of Dr. Christine Ladd-Franklin; in the light of the actual development of the colour sense it becomes possible to reconcile the contradictory facts that vision is tetrachromatic (Hering), and that nevertheless three specific light-rays (those that look to us red, green and blue) are sufficient to reproduce the whole gamut of colour (Helmholtz),—yellow and white make themselves. The imperfectly developed eye of the lower animals is sensitive only to white and black, corresponding to the sensations of the outer zone of our retina. In carboniferous times (when no coloured flowers and no coloured birds existed) animals probably had only achromatic vision. As development went on, the visible spectrum became more specific, yellow and blue were added, as indicated in Figure 448. At present, human beings are in the third stage of development, in which the central zone is sensitive to all four colours, and of course, to all four of the dual colour blends also.

But the actual development of the colour sense makes it easy to suppose (as in the Ladd-Franklin theory) that by a simple chemical reaction the red-greens revert to the yellow out of which they were developed, and then the yellow-blues revert to the white out of which they were developed. See Figure 449. After-images, colour-blindness, and the lack of the colour sense in the periphery of the normal retina are all very readily explained in the light of the fundamental assumption of this theory.

In order for one to read into the Ladd-Franklin theory of colour its real value, accounting for its extraordinary vitality attested by the fact that it has been capable of a variety of formulations changing as the progress of science has demanded change, one must know how she justifiably criticizes the theories of Helmholtz and Hering. For those of the readers who have read the works of scientists in developing theories, it will be understood when it is said that not very often is a definite statement made in refuting other claims, but rather is the inclination to smooth over the difference. This, however, is not true in the case of Dr. Ladd-Franklin, and we find her responsible for this statement:

"It happens that the inadequacies of the two theories are not of the same kind in both cases. The facts which Helmholtz explains are the very ones which are contradictory to the Hering theory, and those which the Hering theory explains are the very ones which are contradictory to the Helmholtz theory. One can put it in this way:—Helmholtz confutes Hering and Hering confutes Helmholtz. The extraordinary vitality which

> these two theories have shown, considering how insufficient they are, can be accounted for only on the ground that they were devised and ardently defended by scientists of great distinction. The fame of Helmholtz especially is so great, and so well-deserved, that it seems nothing less than lése majesté to assume that there is anything inadequate in his theory of colour. The physicists, moreover who alone follow his theory at the present day, cannot be got to consider the facts of colour sensation which it fails to account for—which it is contradictory to."

Let us now start far enough back so that we can lay foundations which will make the theory to be advanced more easily understood. The ancients were struck by the fact that coloured surfaces reflect less light than white ones, and hence they regarded the colours as made up by mixing black and white together. This prevailed up until rather recent times; in fact, the solution of the problem of colour in the physical sense was due to Newton. He proved that white light may be separated into light of different colours, that homogeneous spectral light does not have its colour further changed by a second reflection or absorption. He proved that rays have different refrangibility, and that the colours of natural objects are due to the difference in ways in which they absorb and reflect different sorts of radiation.

Now in order for us to get a little closer to our subject, we must realize that it has lately been put beyond question that the rods and cones represent not simple accidental variations in the shape of elements that are in reality a similar character, but they are fundamentally different. The cones, which in an early stage of development are exactly like the rods, are differentiated out of the rods in the direction of a higher structural development. It is not the cone shape that is the distinguishing mark, however, because the closely pressed together cones of the fovea do not differ in shape from rods, but that they differ markedly in the endings of the cell fiber, the rods terminating in small expansion or end knob, the cones ending in a more complicated structure, and expansion of the finger-like processes which enter severally into connection with different bipolar processes, so that it might be well to consider the rods as the knob-end, and the cones as the finger-end, retinal elements. Therefore, it is easy to understand that in the different degrees of development of the sense of sight, we have the factor responsible for the several capabilities of vision according to the portion of the retina which mediates it. If, therefore, the retinal basis of the light sense is a photochemical process, and the cones only furnish colour sensations, then they must contain more complicated chemical substances than the rods, which do not. Hence, a change will be possible so that in the rods the substance contained might be decomposed all at once, while that residing in the cones would decompose in successive stages. This, then, makes it possible to reason that if the rods furnished colourless vision only, it would be reasonable to expect that the vision of the totally colour-blind might be rod vision only, and this is borne out by the fact that there are well marked instances of foveal blindness in conjunction with total colour-blindness, evidencing the non-existence of normally functioning cones in those cases. There are cases, however, that with total colour-blindness have retained perfect visual

acuity, in which it might be expected that an atavism has occurred in the higher visual centers.

With this rather brief bringing into consideration of rods and cones, photochemical compounds, and higher visual centers, let us turn our attention to the evolution theory of the colour sensations—that of Ladd-Franklin. In respect to most of the characters found in the human animal, one can only study its development from the lower animals, but in the case of colour sense, we are able to perceive its successive stages spread out upon an individual retina. We have miscroscopic evidence that the structure of the retina is anatomically of a higher form of development in the center than at the periphery, so that there is a gradual change when passing from the fovea to the ora serrata with the more highly developed elements (cones) found in the fovea, and occurring more and more sparingly farther out until there are practically none in the extreme periphery.

Corresponding with this fact of structure, is the fact that we get full tetrachromatic colour vision only in the central portion of the retina, and nothing but achromatic vision in the extreme periphery. Experiments substantiate the statement that chromatic vision is mediated by the cones only, and that the rods furnish nothing but achromatic vision. The very first response of a rod or cone to light is probably a purely chemical reaction. Dr. Ladd-Franklin supposes that a light sensitive "mother substance" in the rods and cones is decomposed by the action of light and gives off cleavage products, which arouse the vital activities of the rods and cones and thus start nerve currents coursing toward the brain. She supposes three stages in the development of colour vision, making it well named, an evolution or genetic theory. In the first stage, she supposes that a single cleavage product, which we may call white, is split off by the action of light upon the mother substance, and the vital response is white. In the second stage, representing a higher development, the mother substance is capable of giving off two cleavage products, their splitting off being affected by the length of the waves, so that as a result of the long waves of light, a vital response of yellow is produced, and by the short waves, a vital response of blue. Here, because these second cleavage products are smaller than the original single product occurring in the first stage, we find it possible (they being split from the same cone) to unite them so that they produce a sensation of white, which is consistent with their development. In the third stage, we find the mother substance capable of giving off three cleavage products, again affected by the wave-length, so that the longer wave-lengths split off that which causes a red visual sensation, and the shorter wave-lengths, that which causes a green sensation. Chemically, however, the red and green united would produce yellow so that if split off together they will reform the sensation from which they were developed, namely, yellow. This third development, however, maintains the benefits obtained from the previous stage, so that if they are all three split off together, the red and green uniting to form yellow will unite with the blue to form white.

Without the use of diagram, it is desired to divide the retina in your

minds for consideration into three parts,—namely, the periphery, mid-periphery, and central, so that the third stage of development would occur only in the central, the second stage only in the mid-periphery, and the first or primitive in the extreme periphery. This makes it possible for us to say that the vision of the extreme periphery is achromatic; that of the mid-periphery, dichromatic, and the central which would be a good middle of the retina, tetrachromatic. This, then, begins to give us some understanding of the reason for finding varying areas of colour sensation.

The writer believes that this, the Ladd-Franklin theory of colour, surpasses in clarity the others mentioned, probably by virtue of its simplicity, and accounts for the four chromatic sensations as well as white. There is remaining, then, only an understanding of the sensation of black. Black is the psychic correlate of the absorption, by objects of all the visible light ray frequencies, and can be produced only after exhaustion by pre-exposure to a strong light, and is classified as a colour by virtue of a non-light sensation, and has only one degree of intensity. Here, again, the Ladd-Franklin theory accounts for black in association with the balance of the theory where all other theories account for it independently.

Many attempts have been made to prove the Helmholtz and Hering theories on the basis of their explanation of certain facts. One of these phenomena is that of colour-blindness, but here again the Ladd-Franklin theory has stood the test of time without loss of position. The subject of colour-blindness is the work of unlimited volumes, and there is no desire upon the part of the writer to enter that discussion, except to say the average practitioner will recognize that in cases which may have come to his or her attention, the failure was usually in either red or green, or both, making it reasonable to suppose that the failure may have been in the third stage of development. Despite the fact that some of our best authorities speak of colour-blindness in a rather definite fashion, and say that if it is congenital, it is incurable, so many possibilities enter into our decisions it might be well not to use that term unless extremely well advised. Chroma amblyopia (interpreted—a dimness of vision for chroma) allows in the mind of the practitioner a possibility of correction, and some very important cases have been corrected by training procedures. Developments in later chapters will indicate that toxic conditions do alter chroma interpretation, and it requires no argument to say that these are correctable. To the patient, the diagnosis of colour-blindness is a hopeless thing; and a reasoning individual can understand that if white is a colour, and it is, colour-blindness would mean total blindness.

In conclusion, it should be clear to the reader after an analysis of the subject of colour, that there is a very sufficient basis for the statement made in chapter one—that it would be better to substitute (in speaking of stimuli) achromaticity and chromaticity for the very poor, misused, and often abused terms "degree of non-saturation" and "degree of saturation," thus justifying the title of our work, CHROMAGRAPHOLOGY.

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CASES OF AMBLYOPIA

Patient, male, R. W. H., age 38, February, 1929. Occupation, office worker. Patient came to me complaining of headaches and an inability to do his near point work with comfort. An examination revealed one dioptre of hyperopia in the right eye and one and one-half dioptres in the left. Corrected, his visual acuity was O. D. 20/20, O. S. 5/300. As far as the left eye was concerned, the history was negative. Vision had been exceedingly poor since childhood and nothing had been done to improve it. He had been told by various refractionists that it could in no way be improved. The general history was also negative and with the ophthalmoscope the general picture of the fundus of the left eye was one of retinitis pigmentosa. The external limits of the form field of the left eye were slightly constricted but there were no evidences of scotomata present for either white or colors.

The patient requested that the writer do something to improve the acuity of vision of the left eye. Because of the ophthalmoscopic findings, the writer was somewhat reluctant to treat a case of this character but after fully explaining the probable difficulties which would be encountered, agreed to attempt by means of amblyopic treatments to improve vision in the patient's left eye. Treatments were started on the 13th day of February, 1929, and continued three per week until May 10th, 1930. At first the treatments consisted of visual stimulation by means of the myoculator the sliding chart (previously reported in this Journal) and high frequency as well as occlusion at home.

These later being supplemented by fusion development exercises, using principally the Wells Chart. During the first sixty days there was no appreciable improvement of vision. On May 10th vision had improved

slightly, now being 15/300. From this point on the improvement was steady, visual acuity, being when discharged, 20/24 plus. The patient is now able to read entire stories of two and three pages in the Saturday Evening Post with the good eye occluded and has when corrected, complete comfort at the near point. The fundus still has the characteristic markings of retinitis pigmentosa but the form field is today normal as is the color field.

Patient, male, W. B., age 32, July, 1929. Occupation, office worker. Patient came to me wearing O. U. — 0.25 D. Sph complaining of general fatigue and ocular pains at the end of the days work. An examination revealed the need for a + 1.50 D. Sph at the near point. This correction gave him normal vision in the right eye but the best that could be done with any lens was 20/100 for the left. The history was negative although he had been told during the recent world war that his left eye was considerably poorer than his right. Media was clear with no ophthalmoscopic findings of importance. Both the form and color fields were normal and treatments were suggested to improve the vision of the left eye. This case was treated as was the preceding one, three times each week. The treatments being at first visual stimulation with the myoculator, the sliding chart and High Frequency.

To this was later added the use of fusion development charts as well as the use of the Worth Amblyoscope. The case was discharged on the 28th day of April, 1930. Vision being 20/20 in the left eye. The patient claimed on this date that he could see as well with the left eye as he could with the right in making a comparison test.

C. C. K.

REMOVAL ANNOUNCEMENT

On June 1st, 1930, the editorial and business offices of the American Journal of Optometry were moved to suite 1501 Foshay Tower, Minneapolis, Minnesota. For the first time in the six and a half years of the Journal's existence, it now has individual office space of its own in which to work, which should enable those interested in the Journal to render more capable service to the readers. All correspondence should now be sent to the new office.

CORRESPONDENCE

THE DIATHERMY-MASSAGE TREATMENT FOR CHALAZION

One could also call this the non-surgical treatment for the removal of chalazion. A statistical survey of case records (mine and others) shows that 7% of all hyperopes have blepharitis, chalazion or some other evidence on one or both lids due to the interference in enervation of the

third cranial nerve in its supraorbital branch. Chalazion is more common than expected, until looked for. The prognosis has heretofore called for surgical aid. However, chalazion succumbs readily to massage and diathermy. The massage should be given directly over the affected lid, centering over the nodule in light horizontal and vertical strokes increasing the pressure as the treatments progress. After one or more treatments, the practitioner will perhaps be dismayed to see forming at the palpebral cartilage margin an irritation closely resembling an hordeolum (stye). He should not, however, be dismayed because this is the first sign of the patient's response to treatment as these symptoms show that the chalazion is beginning to drain its softened matter through the meibomian gland to its opening and this draining should be aided by hot compresses, thus assisting in the removal of pus. Indirect diathermy hastens the culmination of the case. The technic is as follows: Apply one block tin electrode (well lubricated) about four inches square over the region of the fourth cervical vertebra. Then taking a palmar electrode in one hand and using the index finger of opposite hand, massage lightly over part of lid under treatment, passing finger from lid over outer canthus to cheek at the same time forming contact with palm of hand, thus lessening and diffusing the irritation and discomfort in breaking the contact. The treatment is not to exceed 30 minutes. The use of low amperage is sufficient and the slight perception of current by patient will be found to be agreeable.

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Box 55,
Stillwater, Minn.
April 18, 1930.

ABSTRACTS

ASTHENOPIA. W. Swain. The Optician. (British). Vol. LXXV, No. 1940, pp. 282-284. 1928.

Asthenopia is, according to Swain, synonymous with eye strain, in its present day significance covers many symptomatic conditions. Most commonly it refers to weariness or fatigue of the eye with inability to use the eyes continuously at near work, and this is the sense in which Donders used the term. After a time the objects become indistinct and confused, work is suspended whilst the sufferer closes his eyes and rubs the lids with his hands or knuckles.

Fuchs, in order to maintain this older meaning, describes it as asthenopia simplex, qualifying it with associated symptoms, *e. g.*,

asthenopia dolens if associated with pain;

asthenopia cephalagica if associated with headache;

asthenopia irritans if associated with irritation, redness or burning.

Such a classification based on associated symptoms appears to Dr. Swain to be preferred to the usual classification according to origin. Indeed it would appear that the history of our knowledge of asthenopia reveals a remarkable lack of standardization of definition—a lack which still leaves the whole question in an unsatisfactory state, nearly as bad as it was when Donders cleared much of the ground. "By degrees the description thereof became more true and more accurate, and what did not belong to it was separated from it. It is evident that in a condition such as this, constituting a part of a floating idea of weakness of vision, occurring with many complications and presenting numerous varieties, according to the time of life and the use made of the eyes, there was great difficulty in sketching a typical picture, so long as the cause of the leading feature of the affection and therefore its nature were unknown."

Donders, according to Swain, enumerated the terms which were applied before the term asthenopia crept into usage, *i. e.*, prior to about 1850, *e. g.*, debilitas visus (Taylor, 1766), amblyopia a topica retinal atonia (Plenck, 1792), affaiblissement de la vue (Wenzel), habetudo visus (Jungken), dullness of sight (Stevenson), affection of retina from excessive employment (Lawrence), languor oculi (Arlt), impaired vision from overwork (Cooper), etc., etc.

It appears, says Swain, from such titles that the origin of asthenopia was obscure—at first in the retina or choroid, then fatigue of retinal nerves; then as a variety of amblyopia with no retinal lesion, indeed as incipient amblyopia. About 1840 the primary cause was sought in the muscular system (although myopes presented a difficulty, *e. g.*, Mackenzie), Sichel in 1848 introducing the term amaurose presbytique. Bohn about this time located asthenopia as fatigue of the motor nerves which he observed in general are more liable to fatigue than sensory ones. Bohn further observed the trouble in near vision, prescribing convex lenses for alleviation. Ruete (1847) stated that exicting causes were not known hovering about an organic basis—congenital and hereditary. A group about this time had also resort to operation, believing asthenopia to be due to spasm of external muscles. When the mechanism of accommodation was more definitely established, V. Carion (1855) believed all cases were faulty accommodation. Donders (1858) attributed all to a hypermetropic structure of the eyeball calling forth continued exercise of accommodation, and also excessive exercise of accommodation relative to convergence specifically mentioning that he referred to "pure" asthenopia. V. Graefe (1856) conceived asthenopia muscularis (due to insufficiency of the internal rectus) and an asthenopia due to actual paresis of accommodation. Donders attributed asthenopia in myopia as due to the asthenopia muscularis of V. Graefe.

Between 1860 and 1890 asthenopia, according to Swain, became divided into (a) accommodative (b) muscular (c) reflex, sometimes (a) and (b) being classed together under a heading muscular. The accommodative varieties of asthenopia were further sub-divided into

(i) weak ciliary (ii) excessive demand as in hyperopia (iii) unequal demand—a "see saw" ciliary action or a doubtful sectional accommodation—in astigmatism (iv) unequal demands binocularly considered as in anisometropia (v) presbyopia. Whilst hyperopia and astigmatism and presbyopia are the most common varieties giving rise to asthenopia simplex and frequently to headache and irritation associations, the other accommodative varieties may be secondary to toxemia; anemia, etc. It is, however, difficult to isolate, except in low degrees, the so-called muscular varieties from the accommodative. Thus correction of refractive error even of small amounts (spherical or astigmatic, aniso-differences) simultaneously eliminates the asthenopia whether it be primarily accommodative or whether it be coincidental muscular and accommodative.

(b) The asthenopia of myopia is more likely, claims Swain, to be muscular whether from concomitancy with the refractive error or from convergence insufficiency. Vertical muscle defects give rise to true muscular asthenopia. So also the cyclo-types. Muscular varieties are generally complex, being associated with headache and, especially in the vertical and oblique errors, may be reflex.

(c) Reflex asthenopia, according to Swain, arises from morbid conditions of neighboring organs, *e. g.*, teeth (Schmidt-Rimpler, 1868), accessory sinuses, etc. Nowadays the old classification—reflex—is further extended. Thus the following nervous and photogeneous, retinal, asthenopias were formerly classed under reflex.

(d) Nervous asthenopia caused by nervous diseases, *e. g.*, hysteria, neurasthenia. Generally, the asthenopia is complex—pain, headache, photophobia, etc., being associated.

(e) Photogenous asthenopia. This arises, says Swain, from excessive and improper illumination, but the question is relative and generally complicated with nervous origins. It has also been called retinal asthenopia. Besides intolerance, hyperaesthesia, albinism, abnormal conditions, abnormal pupillary aperture, etc., it has been suggested that the origin may be muscular (Prentice) in which the ciliary and iris are not working in harmony (iritic asthenopia).

(f) Retinal asthenopia due to fatigue of the retina and consequent difficulty of fixation. There is then a reduction of acuity.

(g) Occupational asthenopia. This type, claims Swain, covers all the preceding varieties but is peculiar to particular occupations. Thus occupations demanding close application of the eyes to close work aggravate muscular and accommodative asthenopia. The viewing of moving objects, *e. g.*, theatre, shopping, motoring, riding in a train, motion pictures, gives rise to a group called panoramic asthenopia (generally lead to headache); these are generally muscular.

Dr. Gould, Mr. E. Clark and many others, claims Swain, lay great stress on the correction of low errors of refraction for the removal of eyestrain, which they (and especially the first mentioned) claim is a very influential factor in the causation of remoter body evils.

Thus Gould claims that 90 per cent of functional cerebral, mental and digestional diseases are due to eyestrain, and cites numerous authorities showing the relative percentage of ocular lesions in groups of diseases, *e. g.*, 100 per cent epileptics have considerable eyestrain. Mr. E. Clarke makes eyestrain a powerful contributory factor (in conjunction with other organic or functional defects), and points out that whilst corection of refractive error may suffice to break up a vicious circle, yet it may be necessary to include other treatment.

Recently, says Swain, it has been suggested that a test for asthenopia consists in viewing a motion picture on the observed ground that more fatigue is experienced by reading a magazine than by viewing a motion picture, so that if people suffer from eyestrain after viewing a motion picture, they are less likely to perform other ocular work (Irvine and Weymann). Other forms of asthenopia have been traced to (a) imaginary (b) insufficiency of retinal pigment (c) squeezing eyelids together (d) sequel to atropinization, etc.

In conclusion, claims Swain, it should be remembered that most eyes which show asthenopia possess high acuity; the higher the acuity the greater the tendency to asthenopia. Such eyes cannot tolerate readily a blur (external) in printing, etc., or dancing type as in a moving railway carriage. There then immediately arises a sense of strain. So also in inadequate illumination as opposed to excessive glare. T. O. B.

TREATMENT OF DISEASES OF THE EYE BY ULTRA-VIOLET LIGHT. O. G. Hume. The Eye, Ear, Nose and Throat Monthly. Vol. 7, No. 9, pp. 465-469. 1928.

Hume's paper deals largely with the therapeutic action of ultra-violet in various diseases of the anterior portion of the eye. He mentions perniciuos myopia in children however and has this to say in regard to the use of ultra-violet in this type of myopic case.

"We cannot leave the subject of ultra-violet therapy without mentioning the fact that it may be possible to delay the progress of many cases of pernicious myopia in childhood by utilizing ultra-violet radiation with a view to increasing the calcium content of the blood. Recent work in the U. S. on the pathology of myopia points to the fact that nearly all cases of fully developed myopia have a low calcium content in the blood, and there is also an insufficient amount of pressor substances. We are aware that a low blood calcium does not always indicate low calcium reserve and vice versa. The recent work of Keith tends to show that the origin of myopia starts in most cases from a badly laid sclerotic and posterior pole of the choroid, which is made still more soft by lack of calcium in the structural supporting layers." C. C. K.

ANNOTATIONS AND SOCIETY PROCEEDINGS

The American Journal of Optometry is the Official Organ of the American Academy of Optometry, as well as the Organ of the Arkansas, Delaware, Indiana, Iowa, Maine, Maryland, Michigan, Minnesota, Nebraska, North Dakota, Oklahoma, Pennsylvania, South Dakota, Vermont and West Virginia Optometric Associations.

The following gentlemen have consented to supply items of interest from their respective sections, acting in the capacity of

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A. O. A. MEETS IN BOSTON

The annual meeting of the American Optometric Association will be held in Boston, Massachusetts, the week of June 16th. The New England Optometrists who are hosts at this time have arranged an elaborate program containing many educational features and other activities which should be of interest to all optometrists. A large number of displays will be set up at the Hotel Statler at which the meeting will be held and a large attendance is expected. Among the speakers will be Dr. Charles Sheard of the Mayo Foundation, Rochester, Minnesota, and Dr. Edwin Forbes Tait of the Pennsylvania State College of Optometry. The principal business that will come before the Association will be the election of officers and trustees as well as a discussion on the advisability of increasing the annual dues.

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PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College of Optometry has announced the inauguration of a drive for funds, these to be used in erecting a new college building and refraction hospital. The drive was opened on May 10th at a dinner at which $52,000 was pledged. In June the school in commemorating the 10th anniversary of its founding will hold a week of graduate work in Philadelphia.

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OKLAHOMA STATE ASSOCIATION

Dr. E. B. Alexander, Secretary of the Oklahoma Board of Examiners in Optometry, announces that a series of newspaper articles to be released weekly are now available to optometrists of that state. These articles dealing with Eye-sight conservation are to be distributed to the local editors in various Oklahoma com-

munities. All papers of the state will be served with this material. The Oklahoma State Association of Optometry is standing all expense for the service in that state and should other state societies wish to have this service, same can be supplied them for a $12.00 a release.

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MINNESOTA BOARD OF EXAMINERS

The Minnesota State Board of Examiners in Optometry will conduct examinations on July 7th and 8th, 1930, in the Senate Chamber of the Old State Capitol, St. Paul, Minnesota. Applicants should apply to Dr. E. H. Kiekenapp, Faribault, Minnesota, for registration.

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NORTHERN INDIANA ASSOCIATION

The Northern Indiana Optometric Association held its monthly meeting at LaPorte, Indiana. The chief speakers were Dr. E. E. Curtis and Dr. Parker. Dr. Curtis spoke on the "Relation of the Spine and Nerves to the Eye," giving also a clinical demonstration of the technique used in non-operative treatment for Squint. Dr. Parker spoke on color field charting. The meeting was well attended.

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OKLAHOMA BOARD OF EXAMINERS

Dr. E. B. Alexander, Optometrist of Duncan, Oklahoma, Secretary of the Board of Examiners in Optometry for the State of Oklahoma, announces that this Board will hold an examination on the 7th and 8th of July at the Huckins Hotel, Oklahoma City, Oklahoma.

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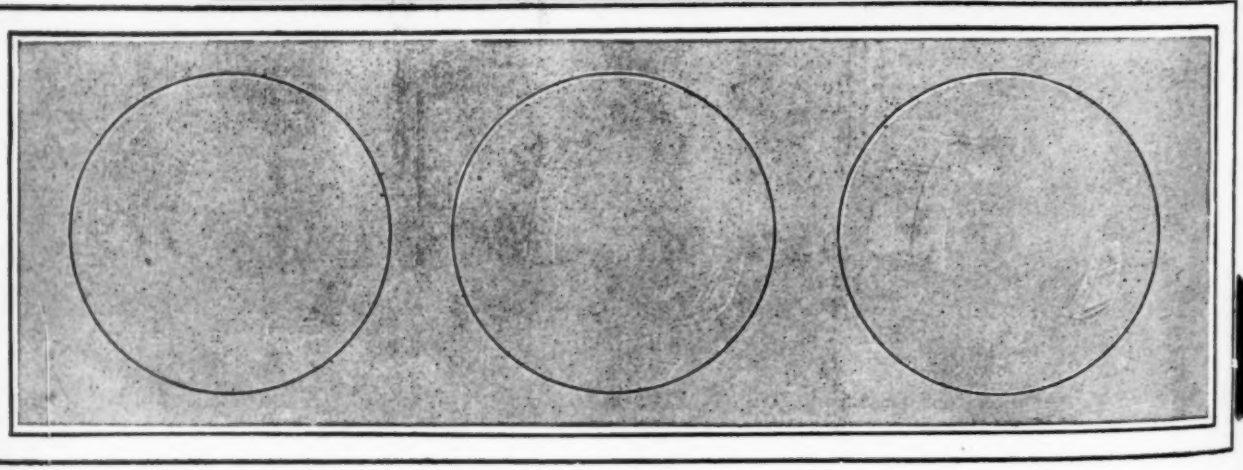

ORTHOGON--SOFT LITES IN THREE SHADES